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REVISION C
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ORGANIZATIONAL INSTRUCTION

MAGNETIC PARTICLE INSPECTION

OPR(s)	OPR DESIGNEE
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CHECK THE MASTER LIST AT: http://inside.msfc.nasa.gov/MIDL/
VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Revision	New Baseline	9/09/02	This OI replaces QS10-QA-010 Rev. C. When changing to the new numbering scheme outlined in QS-A-001 rev. F, there was a duplication of numbers; therefore this OI was changed to the next sequential number of QS-QA-028. Format and numbering change to implement requirements of QS-A-001 rev F.
Revision	A	09/19/03	Changes made to reflect new organization and electronic forms. Revised document reference in Applicable Documents.
Revision	B		Revised to bring document in compliance with the HQ Rules Review Action (CAITS: 04-DA01-0387). Changes were also made to reflect S&MA organizational name changes (i.e., QS to QD).
Revision	C	11/22/05	Administrative Revision changed OPR

MAGNETIC PARTICLE INSPECTION

1. SCOPE

1.1 Scope. This instruction provides general requirements for dry visible and wet fluorescent magnetic particle inspection of flight hardware, structural welded assemblies, subassemblies, components, pressure vessels, and pressure boundaries. Magnetic particle inspection shall be performed using the yoke, prod and coil method. Sizes and shapes of items to be inspected are unrestricted provided adequate magnetic flux can be maintained.

1.2 Purpose. This instruction complies with MPG 8730.1.

1.3 Applicability. This instruction applies to all Safety and Mission Assurance Office (S&MA), NDE Team, and contractor personnel that perform magnetic particle inspection.

2. APPLICABLE DOCUMENTS

ASTM E 1444-01	American Society for Testing And Materials, Standard Practice for Magnetic Particle Examination
MPR 8730.1	Inspection and Testing
MWI 3410.1	Personnel Certification Program

3. DEFINITIONS

a. Coil. For longitudinal magnetization of shafts, spindles, axles, and similar small parts, the hand held coil offers a convenient method for inspecting for transverse cracks.

b. Prods. Two hand-held electrodes are pressed against the surface of a part to make contact for passing magnetizing current through the metal. The current passing between the two contacts creates a field suitable for finding defects with magnetic particles.

c. Yoke. U-shaped cores of soft iron with a coil wound around the base of the U. When alternating current or rectified alternating current is passing through the coil the two ends of the core are magnetized with opposite polarity, and the combination is an electro-magnetic yoke, with a magnetic field similar to that of a permanent horseshoe magnet. A yoke may be used to induce a longitudinal field in a part.

4. INSTRUCTIONS

4.1 Surface Preparation.

4.1.1 The maximum surface temperature shall be 600°F.

4.1.2 Note:Surfaces may be inspected in the as-welded, as-rolled, as-cast, or as forged condition providing that surface irregularities will not mask indications of unacceptable discontinuities. In such cases, grinding or machining may be necessary to provide an acceptable surface for examination.

4.1.3 The surface to be examined and one inch on each side shall be dry and free of dirt, scale, welding slag or flux, oil or other extraneous matter that might interfere with the mobility of the examination medium. Cleaning shall be accomplished by grinding, wire brushing, grit or vapor blasting, detergent cleaning, or solvent cleaning.

4.2 Sequence of Operation.

4.2.1 Examination shall be carried out by the continuous method; that is, the magnetizing current shall remain on during the period the examination medium is being applied and while excess medium is being removed.

4.3 Examination Medium.

4.3.1 The finely divided ferromagnetic particles used for detection of discontinuities shall be of a color to provide adequate contrast with the background of the surface being examined. This material shall be of high permeability and low resistivity and of suitable sizes and shapes to readily produce magnetic particle indications. Particles selected shall be red, gray or black dry visible particles or wet fluorescent particles.

4.3.2 The dry particles shall be applied by lightly dusting the surface to be inspected. It is essential to observe carefully the formation of indications while powder is being applied. Fluorescent particles suspended in a liquid vehicle shall be applied either by gently spraying or flowing the suspension over the area to be inspected.

4.3.3 Excess particles shall be removed by means of a gentle air-stream, usually a hand-powered blower. Care shall be taken not to disturb or remove lightly held powder patterns.

4.4 Equipment. Any suitable and appropriate means for establishing the necessary magnetic flux may be employed, such as passing a current through the material, using a magnetic yoke (for surface discontinuities only), or wrapping the part with a coil through which a magnetizing current is passed.

4.5 Equipment Calibration. Equipment calibration and calibration interval shall be performed in accordance with ASTM E-1444-01 "Standard Practice for Magnetic Particle Examination" and the equipment's manufacture's manual.

4. 6 Demagnetization. Demagnetization following examination is required where residual magnetism interferes with subsequent processes or usage.

4. 7 Illumination. Illumination shall be sufficient to detect the smallest indication within the workable capabilities of the test; generally this will be 100 foot-candles at the test surface as a minimum for dry particles. For fluorescent particles, portable or hand held black lights will produce an intensity greater than 1000 mw/cm2 when measured at 380 mm (15 inches) from the black light source.

4.8 Examination Coverage. Examinations shall be conducted with sufficient overlap to assure 100 percent coverage at the established test sensitivity.

4.9 Direction of Magnetization. At least two directions shall be carried out on each area, with contacts placed so the lines of flux in one examination are perpendicular to the lines of flux in the other.

4.10 Technique.

4.10.1 PROD Technique

4.10.1.1 Magnetizing Technique. Magnetization shall be accomplished by portable prod type electrical contacts pressed against the surface in the area to be examined. To avoid arcing, current shall not be permitted to flow until after the prods have been properly positioned, and it shall be turned off before prods are removed.

4.10.1.2 Prod Spacing. Prod spacing shall be a maximum of 8 inches. Shorter spacing may be used to meet the limitation of geometry of dimensions of the area being examined, or to increase the sensitivity. However, prod spacing of less than 3 inches is usually not feasible due to the banding of particles around the prods. The prod tips shall be kept clean and dressed and the contact areas of the test surface free from dirt, scale, oil, etc., to minimize electrical arcing. If a source of magnetizing current with an open circuit voltage of over 25V is used, lead, steel or aluminum, rather than copper tipped prods are recommended to avoid copper penetration.

4.10.1.3 Magnetizing Current. Direct or rectified magnetizing current shall be used at a minimum of 100 and a maximum of 125amp/inch of prod spacing for sections ¾ inch thick or greater. For sections less than ¾ inch thick, amperage shall be 90 to 100amp/inch of prod spacing.

4.10.2 Coil Technique

4.10.2.1 Magnetizing Technique. Magnetization is accomplished by passing current through a multiturn coil looped through or around the part, to be examined. This produces a magnetic field parallel to the axis of the coil.

4.10.2.2 Magnetizing Current. For encircling coils, direct or rectified current at 35,000 ampere-turns, divided by the sum of 2 plus the length-over-diameter ratio (L/D) of the test part 35,000 ampere-turns/(2+L/D) shall be used for magnetization.

4.10.2.3 This formula provides adequate field strength for parts with an L/D ratio greater than or equal to 4. For ratios down to 2 and for smaller parts magnetized in a larger, fixed-size coil, the formula shall be 45,000 ampere-turns divided by the length-over-diameter ration. For L/D ratios less than 2, alternate magnetizing methods shall be used. When the magnetizing coil is made of cable wound around the test part, the coil's turns shall be closely spaced. The effective field extends for about 6 inches on either side of the coil; longer parts shall be magnetized in sections

4.10.2.4 For through-coils, the amperage specified in sections 4.10.2.2 and 4.10.2.3, divided by the number of turns, shall be used.

4.10.2.5 The second examination required by section 4.9 may be made by a different magnetization means.

4.10.3 Yoke Technique

4.10.3.1 The yoke technique only detects discontinuities which open to the surface.

4.10.3.2 Alternating or direct current electromagnetic yokes or permanent magnet yokes shall be used, and shall meet the requirements of section 4.5.2. Except for materials ¼ inch or less in thickness, alternating current yokes are superior to direct or permanent magnet yokes of equal lifting power for the detection of surface discontinuities.

4.10.3.3 The second examination required by section 4.9 may be made by a different magnetization means.

4.10.4 Direct Contact Technique

4.10.4.1 Magnetization Technique. Magnetization is accomplished by passing current end-to-end through the part to be tested, which produces a "circular" magnetic field perpendicular to the current flow through the part.

4.10.4.2 Magnetizing Current. Direct or rectified current shall be used at 700 to 900 amp/inch of part for diameters up to 5 inches, 500 to 700 amp/inch of part with diameters 5 to 10 inches, and 300 amp/inch of part with diameters greater than 10 inches.

4.11 Evaluation of Indications.

4.11.1 Mechanical discontinuities at the surface are indicated by the retention of the examination medium. All indications are not necessarily defects, since certain metallurgical discontinuities and magnetic permeability variations may produce similar indications which are not relevant to the detection of unacceptable discontinuities.

4.11.2 Any indication which is believed to be nonrelevant shall be regarded as a defect and shall be re-examined to verify whether or not actual defects are present. Surface conditioning

may precede the re-examination. Nonrelevant indications which would mask indication of defects are unacceptable.

4.11.3 Relevant indications are those which result from unacceptable mechanical discontinuities. Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

4.12 Accept/Reject Criteria.

4.12.1 Accept/Reject criteria shall be noted on the engineering drawings or other approved design documentation provided to the individual performing the inspection by the design engineer prior to indication evaluation.

4.12.1.1 In the event that accept/reject criteria is not available then any relevant indications as defined in section 4.11 shall be considered unacceptable and shall be cause for rejection.

4.12.2 Welds

4.12.2.1 Only indications with major dimensions greater than 1/16 inch (1.6 mm) shall be considered relevant.

4.12.2.2 Unless otherwise specified, the following relevant indications are unacceptable and shall be cause for rejection:

a. Any cracks and linear indications;

b. Rounded indications with dimensions greater than 3/16 inch;

c. Four or more rounded indications in a line separated by 1/16 inch or less edge to edge;

d. 10 or more rounded indications in any 6 square inch of surface with the major dimension of this area not to exceed 6 inches with the area taken in the most unfavorable location relative to the indications being evaluated.

4.12.3 Weld Edge Preparation

4.12.3.1 Unless otherwise specified, the following relevant indications are not acceptable:

a. laminar discontinuities over 1 inch long and other linear indications over 3/16 inch long;

b. rounded indications greater than 3/16 inch;

c. four or more indications in a line separated by 1/16 inch or less, edge to edge.

4.12.4 In the event that no indications are detected, stamp and date the work authorizing document,(if electronic, affix password protected initials/signature) complete the record of magnetic particle inspection (Appendix A), attach it to the work authorizing document, and forward a copy of the record to the appropriate records center.

5. NOTES

5.1 ASTM E 1444-94 may be used as a guideline to perform magnetic particle inspection.

5.2 Reference Documents. The following reference documents provide additional information concerning the subject of Magnetic Particle Inspection:

MSFC-STD-1249	Standard NDE Guidelines and Requirements for Fracture Control Programs

5.3 The magnetic particle inspection record (Appendix A) is maintained by the QARC for flight hardware. For Test Lab, the records are attached electronically or scanned in, to the electronic Test Preparation Sheet records, and stored as required by procedures. The record will be provided to other customers are required by procedures or work requests.

6. SAFETY PRECAUTIONS AND WARNING NOTES

None.

7. APPENDICES, DATA, REPORTS, AND FORMS

Appendix A Record of Magnetic Particle Inspection

8. RECORDS

None.

9. TOOLS, EQUIPMENT, AND MATERIALS

The following equipment and materials are necessary to perform magnetic particle inspection:

a. Probe

b. Yoke

c. Field Strength Indicator

d. Dry or wet fluorescent particles

e. Bulbs

f. Black light

10. PERSONNEL TRAINING AND CERTIFICATION

All personnel that perform magnetic particle inspection for acceptance of hardware are required to be trained and certified in accordance with MWI 3410.1.

11. FLOW DIAGRAM

None.

Appendix A

Record of Magnetic Particle Inspection MSFC/Quality Assurance Office	Report #: _____	Insp Date: _____
Project: _____	TPS #: _____	Dwg #: _____

Part 1 - Test Specimen Data

Nomenclature: _____	Flight:___ GSE:___ Other: ___
Material Type: _____	Quality Sensitive: _Yes _No
Part Number: _____	Weld Class: _____
Inspection Procedure: _____	Weld #: _____

Part 2 - MT System Data

Type Machine: _____	Type Magnetization: _____
Serial Number: _____	Method Used: Wet _____ Dry _____
Type Current: AC _____ DC _____	Fluorescent _____
Prod Spacing: _____	Visible _____

Part 3 - Inspection Results

Part 4 - Verification

	Name and ASNT Level	Stamp	Date
Inspection Conducted By:	_____	_____	_____
Interpreted By:	_____	_____	_____